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Yield Probabilities as a Markov Process

By Don Bostwick

The shape and consequences of fortuitous events are subjects of much discussion in economics. Wheat yields on dryland are one member of such a set of events. Much research effort has been devoted to establishment of causal factors in observed yield variability and in attempts to derive probability models without waiting for causal understanding. The discussion that follows is another in the list of attempts of the latter kind. Thanks are due James S. Plaxico of Oklahoma State University, others of the GP-2 Technical Committee, and members of the Farm Economics Division, Economic Research Service staff in Washington, D.C., who read the manuscript and suggested improvements.

MANY of the statistical techniques used to fit yield data to probability models require the assumption of randomness in the distribution of the observational data. This requirement has not been completely satisfactory—an autocorrelation ghost persists in stalking such models, even though hidden in residual error terms.

In the two approaches that follow, the first attempts to invest the ghost with some statistical substance, via a bunchiness test. The second combines a bit of inductive reasoning with the results of the bunchiness tests, toward a hypothesis that autocorrelation of a special sort is not a ghost and as a consequence can be put to work making Markov chains.

Almost any dryland farmer or researcher in the Great Plains who has thought about it believes that wheat yields and/or the weather phenomena underlying them, are *not* an independent and random series over time. On the contrary, these people believe that yields and/or weather phenomena tend to bunch. Bunchiness is the tendency for the phenomena to come in runs of like years, which differ statistically from those expected under random conditions.

R. J. Hildreth of the Texas Agricultural Experiment Station reported tests of the bunchiness hypothesis using annual precipitation in North Dakota over a 40-year period.[1] These tests were somewhat inconclusive.

Greve, Plaxico, and Lagrone report bunchiness tests on production for four enterprises and annual rainfall in northwestern Oklahoma (*1*).* These tests indicated significant bunching of observations in each series of data.

Both of these papers report a nonparametric test developed by Wallis and Moore about 1941. This test requires a long series and a definition of "troughs" and "peaks" of cycles in the series. "In a series of N independent random observations the expected number of completed runs of length d of the signs of first difference ($d+$ signs or $d-$ signs) is:

$$U=\frac{2(d^2+3d+1)(N-d-2)}{(d+3)!}\text{"} \quad (8, \text{p. } 234).$$

The test statistic X_p^2 is computed according to the formula

$$X_p^2=\frac{(u_1-U_1)^2}{U_1}+\frac{(u_2-U_2)^2}{U_2}+\ldots+\frac{(u-U)^2}{U},$$

in which U is calculated as above, and u is the number of runs of length d observed in the data.[2] This is distributed approximately as 6/7 X^2 for two degrees of freedom if $X_p^2<6.3$; for $X_p^2>6.3$, it follows the standard X^2 distribution for $2\frac{1}{2}$ degrees of freedom.

A series of 74 county average yields and a series of 63 annual precipitation observations for Hand County, S. Dak. (*6*, pp. 37–38), [3] were tested for bunchiness. The observation was coded 1 when it was more than 0.5 standard deviation below the mean; 2 when it was within 0.5 standard devia-

[1] R. J. Hildreth, *Bunchiness of Precipitation Data and Certain Analytical Implications*, paper presented at Methodology Workshop, GP-2 Technical Committee, Lincoln, Nebr., May 5–7, 1959.

* Italic numbers in parentheses refer to Literature Cited, page 55.

[2] The variables u and U in the last term of this expression are not subscripted for two reasons: First, there is no necessary limit to the length of runs that may be included in the analysis; second, the last term is open-ended, so the subscript would be of the form, $U_{i\to x}$ rather than the implicit form, $U_{i=x}$ of the previous terms.

[3] Myrick, D. C. An Experiment in Land Use Planning Illustrated by Hand County, South Dakota. Unpublished Ph. D. Thesis, Harvard University, Oct. 1956, pp. 127–128, 369, 378.

tion above or below the mean; and 3 when it was more than 0.5 standard deviation above the mean. A bunch (or run) is defined by a series of identical code numbers. The observed runs were as follows:

Number of runs observed

Runs of years	*Yields*	*Precipitation*
1	27	32
2	7	8
3	4	5
4	1	0
5	2	0
6	0	0
7	1	0

The hypothesis under test is that the observed runs are random. The critical value of X_p^2 at the 0.05 level is 5.13; at the 0.10 level, it is 3.95. The calculated X_p^2 for the yield data was 6.17, and for the precipitation data, 3.92. Thus, we can reject the hypothesis of randomness in the Hand County yield data with a 5-percent probability of being wrong. We can reject the hypothesis of randomness in the precipitation data only if we are willing to accept a somewhat greater than 10-percent probability of being wrong. These results agree with the Oklahoma results, at least with respect to bunchiness of yields.

Data on wheat yields on State Lease Land from Judith Basin and Fergus Counties, Mont., gathered by Hjort (*2*, table II, Appendix A, pp. 71–74), were also tested for bunchiness using the Wallis and Moore procedure. These data were 37 individual yield series with observations in each series for a period of 14 to 23 years, ending with the 1956 crop. I believe that together they are a reasonably representative sample of the geographic area and the span of years. This test is for bunchiness of yields on individual farms over a two-county area; they differ from the preceding tests, which were for bunchiness of county average yields. The 678 observations were distributed in runs as follows:

Runs of	*Number observed*
1	257
2	80
3	35
4	12
5	5
6	5
7 or more	7

The calculated X_p^2 for these data was 1,747.81. Lumping the last three categories into runs of 5 or more resulted in a calculated X_p^2 of 199.68. The maximum value of X^2 at the .0005 level is 17.7, so we can be highly confident of bunchiness in the Montana yield data.

The data we have tested for Oklahoma, South Dakota, and Montana support a hypothesis of bunchy yields. This finding compromises the use of traditional probability analyses, which assume randomly distributed sequential observations. What is needed now is a causal hypothesis about the sequential dependence of yields, and a technique for calculating probabilities without violating this dependence hypothesis. They are discussed in the section that follows.

Yield Probabilities as a Markov Process

We have indicated that wheat yields tend to be bunchy or nonrandom in occurrence. A possible explanation for this bunchiness is the use of summer fallow in the wheat rotation. Summer fallow is a device for aiding the growth of a wheat crop from one year to the next. The wheat grown in Montana this year was grown almost entirely on last year's summer fallow, and next year's wheat will come from this year's fallow. So any given wheat crop is functionally related to weather, especially precipitation, over a 2-year period.

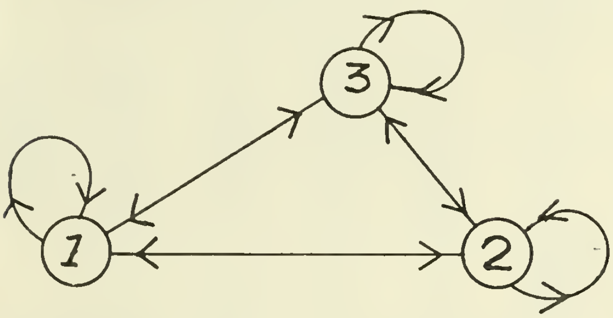
A very low yield this year would probably mean low soil moisture storage in the summer fallow. Therefore, next year would need to be very wet for next year's wheat crop to be a bumper one. If the odds favor normal rainfall next year, the wheat crop is likely to be less than normal. Similarly, a very high yield this year should mean good soil moisture in the fallow for next year's crop. The odds should be against a low yield next year; the crop should be normal or better. The hypothesis is that wheat yield on fallow in any year i is a function of precipitation in year i, and in year $i-1$.

This hypothesis happens to be very close to the basic assumption required of a Markov chain. Instead of relating yield to precipitation in sequential years, let us hypothesize that yield in year i is a function of yield in year $i-1$, by way of their common relationship to precipitation in both years. Let us further specify that yield in year i is a random variable with respect to any year in the series other than $i-1$. Year i, of course, is

related to the succeeding year i+1, when it will itself be year i−1, but it is then a different datum. The hypothesis deals only with sequential pairs of years from what is otherwise a random series.

My favorite example of a Markov chain concerns a frog in a lilypond. The frog is sitting on one of a finite number of lilypads and will presently jump. He may go straight into the air and land back on his starting pad, or he may land on any other pad on the pond. The problem is to assign a probability to the frog's landing on any given pad, starting from any given pad. It is against the rules to land in the water, so there is a probability of 1 (one) that he will land on *some* pad.

The possibilities are shown schematically for a pond containing only three pads.



All told, there are nine possibilities, only three of which are pertinent to any one situation. The frog must start somewhere, so the six possibilities that arise from his starting elsewhere are eliminated.

According to our hypothesis, the frog does not jump at random. The probability of his arriving at pad 2, starting from pad 1, differs from the probability of arriving at pad 1 or pad 3. And the probability of arriving at pad 2, starting from pad 1, differs from the probability of arriving at this pad starting from pad 2 or 3. If he has enough jumps, the frog will eventually build a history including jumps from all three pads to all three pads. From these data, all manner of probability statements can be computed. Let us observe a further example of the same process.

A Markov process requires the definition of starting "states" (the pads from which it is possible to jump), and a transition matrix of probabilities attached to jumping from any state to any state in one move. In the frog example, this would be a 3 x 3 matrix.

The example that follows deals with probabilities of dryland wheat yields on a modal Montana farm. Starting "states," in yield per acre, were defined according to the levels of income they would produce. The farm organization—a 1,200-acre dryland wheat farm in north-central Montana, growing 578 acres of wheat each year on summer fallow—was assumed to be constant. Cost data were based on budgets developed by LeRoy Rude (7, Appendix III, pp. 20–22),[4] and a constant price of $1.65 per bushel for wheat was assumed.

Five starting states were defined by the following yields:

1. Less than enough to cover cash costs ($3,815), or $S_1 < 4$ bu./acre.
2. Cover cash costs but less than family living ($6,867), or $4 \leqq S_2 < 7.2$.
3. Cover cash costs and family living but less than interest on investment, or annual debt payments ($17,357), or $7.2 \leqq S_3 < 18.2$.
4. Cover cash costs, family living and annual debt payments, but less than depreciation ($19,932), or $18.2 \leqq S_4 < 20.9$.
5. Cover all costs, leaving a surplus, or $S_5 \geqq 20.9$.

The yield data from Hjort (*8*) provided 612 paired sequential yield observations with the following distribution:

State in year i	Yield state in year i+1: 1	2	3	4	5	Row sum
1	5	5	14	4	9	37
2	5	11	33	1	4	54
3	12	29	175	30	58	304
4	1	1	32	12	22	68
5	5	4	43	25	72	149
						612

The transition matrix P is computed by setting the sum of each row equal to one and calculating the percentage of the total represented by each component in the row. The transition matrix for these data is:

Starting state	Yield state next year: 1	2	3	4	5
1	.13514	.13514	.37838	.10811	.24324
2	.09259	.20370	.61111	.01852	.07407
P=3	.03947	.09539	.57566	.09869	.19079
4	.01470	.01470	.47059	.17647	.32353
5	.03356	.02684	.28859	.16779	.48322

[4] Rude's capital values were adjusted to reflect the current market and a $3,000 allowance for family living was assumed.

Each component is the probability of arriving next year at the state given by the column heading, starting from a state this year indicated by the row heading (p_{ij}=probability of transition from state i to state j). Thus, if yield this year is less than enough to cover cash costs (state 1), the probability of next year's yield falling in the same category (S_1) is .135; and the probability of next year's yield producing a surplus (S_5) is .243, and so on.

This is an ergodic Markov process; it is possible to go from any state to any other in a finite number of steps. The P^2 matrix gives the probability of a given yield state 2 years after a given starting state. It is the square of the transition matrix. The $P^2 \times (P) = P^3$ matrix would give the probabilities 3 years after the start, the $(P^2)^2 = P^4$ matrix, 4 years after the start, and so on.

Starting state — Yield state 2 years hence

$$\begin{array}{r} \\ 1 \\ 2 \\ P^2=3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} .05546 & .09000 & .47261 & .11435 & .26759 \\ .05825 & .11456 & .54140 & .08979 & .19599 \\ .04474 & .08625 & .50612 & .11227 & .25062 \\ .03537 & .06115 & .46186 & .13373 & .30788 \\ .03709 & .05297 & .41364 & .14330 & .35300 \end{bmatrix} \end{array}$$

The T matrix is defined as the matrix P^n such that each row is the same probability vector W, and all components of W are positive. These components of W are the probabilities of the process being in any given state at some future year i+n and are independent of the starting state in year i.

There are several methods of computing the T matrix, or W vector. The hard way is to square the P matrix and the successive product matrices until all row vectors are identical, to some limit of precision. This procedure was carried out on an electronic computer to the P^{32} matrix shown below. If a computer is not available, there is a method that shortens the computation involved. This requires multiplying the first row of the P matrix by the P matrix, producing a row that can be called 1′ in a new matrix. Then this row 1′ is multiplied by the P matrix, producing a row 2′, which is again multiplied by the P matrix, producing 3′, and so on. This process is continued until two successive rows of the P′ matrix are identical to some limit of precision. These rows are W vectors.

The third procedure is to compute:

$$\lim_{n\to\infty} P^n = T$$

This was also done on an electronic computer producing the P^n matrix shown below. A comparison of the P^{32} and the P^n matrices gives some indication of the rate of convergence of these yield data.

The stationary vector:

$$W = [.04332 \quad .07655 \quad .47601 \quad .12194 \quad .28215]$$

indicates that the long-run probability of being in yield state 1 (<cover cash costs) is .043+, of being in yield state 5 (a surplus) is .282+, and so on.[5]

Starting State — Yield state 32 years hence

$$\begin{array}{r} \\ 1 \\ 2 \\ P^{32}=3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} .04495 & .07939 & .49381 & .12661 & .29373 \\ .04424 & .07813 & .48597 & .12460 & .28907 \\ .04419 & .07804 & .48543 & .12446 & .28875 \\ .04416 & .07799 & .48513 & .12438 & .28857 \\ .04417 & .07802 & .48528 & .12442 & .28866 \end{bmatrix} \end{array}$$

Starting state — Yield state $n\to\infty$

$$\begin{array}{r} \\ 1 \\ 2 \\ P^n=3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} .04332 & .07655 & .47601 & .12194 & .28215 \\ .04332 & .07655 & .47601 & .12194 & .28215 \\ .04332 & .07655 & .47601 & .12194 & .28215 \\ .04332 & .07655 & .47601 & .12194 & .28215 \\ .04332 & .07655 & .47601 & .12194 & .28215 \end{bmatrix} \end{array}$$

If we are now in yield state i, after how many years can we expect to be in state i again? The average expectation of return to any starting state i is the mean recurrence time for that state. This is a vector R, each component of which is the reciprocal of the corresponding component of the fixed (or stationary) vector W (*5*, p. 413). Thus the mean recurrence vector for the five yield states is:

$$\begin{array}{r} \\ 1 \\ 2 \\ R=3 \\ 4 \\ 5 \end{array} \begin{array}{c} \text{Years} \\ \begin{bmatrix} 23.084 \\ 13.063 \\ 2.125 \\ 8.201 \\ 3.544 \end{bmatrix} \end{array}$$

[5] Procedures were based on Kemeny and Snell's *Finite Markov Chains* (*4*, ch. 4). Thanks are due Charles J. Mode, Statistician, Montana Agricultural Experiment Station, for computation of the P^n, P^{32}, mean first-passage, and variance of mean first-passage matrices.

The next logical step is the computation of the mean first-passage time; this is the mean number of years required to arrive in any given state, starting from any specified state. The mean first-passage matrix is as follows:

Starting state — Mean first-passage time (in years)

Starting state	1	2	3	4	5
1	23.0787	14.3486	2.6037	9.0156	4.8929
2	24.1128	13.0616	1.8952	10.0552	5.8865
3	25.7920	15.0420	2.1008	9.1133	5.1555
4	26.6988	16.6093	2.4748	8.2008	4.3565
5	26.2586	16.6581	3.0054	8.1329	3.5441

Note that the values on the major diagonal are approximately those of the mean recurrence vector R above. The differences arise from rounding errors.

A variance and standard deviation estimate can be attached to each of the values in the mean first-passage matrix. The standard deviation matrix is given below.

Starting state — Standard deviation of mean first-passage times

Starting state	1	2	3	4	5
1	25.1911	15.1479	2.1143	8.4257	4.6676
2	25.2735	14.8801	1.6683	8.4363	4.6667
3	25.3866	15.1939	1.8974	8.4151	4.6125
4	25.4077	15.2646	2.1359	8.2932	4.4247
5	25.4141	15.2877	2.2764	8.2556	4.1064

The mean first-passage times from these yield data have uniformly large standard deviations. A person using this matrix as a prediction might do well to consider carefully before he stakes a great deal on his prediction.

The reliability of the various probabilities derived from a Markov chain analysis can best be checked by comparison with empirical data. This has not been done with the yield probabilities derived in the foregoing pages. But another way to lend support to a hypothesis, at least for pragmatists, is to describe the many useful applications that would obtain if the hypothesis were valid. The rest of this discussion is an attempt to do just this.

Applications of the Markov Process to Farm Financial Management

A Cash Carryover Decision

How much cash from the year's income should a particular farmer allocate to his cash carryover account? The decision strategy should take account of: (1) the ability to withdraw cash from the crop income this year; (2) the probability of needing cash to cover a short crop next year; (3) the fact that over the long run, no more can be withdrawn from this account than has been put into it; and (4) the undesirability of putting more in than is required over the long run. Let us assume that $3,694 will cover cash operating costs in any given year, and that this is the desired state of the cash carryover account over the long run.

The conditions defined in the paragraph above, and the probabilities from the transition matrix are the raw materials from which a decision formula may be constructed. The formula needs to allow for inputs to and withdrawals from the cash carryover account. These are defined as positive and negative levels of activity in the solution vector. One way of getting a negative level of activity is to subtract one p_{ij} from another, choosing the j's so that the difference is negative when the starting state yield is low and positive when it is high. The result must be multiplied by the modal value assigned to the cash carryover activity, which in this example is $3,694. If the formula does not make use of all components in the ith row and/or manipulates them other than additively, it is necessary to calculate a correction factor that takes account of this omission and manipulation of components.

A generalized formula for the desired strategy is:

$$\text{Cash}=(af(p_{ij}))b$$

in which a is the correction factor, b is the modal value chosen for the activity, and $f(p_{ij})$, states the particular way in which probabilities from the transition matrix are to be manipulated. The value of "a" depends on the $f(p_{ij})$, and is calculated according to the generalized formula:

$$a=\frac{b}{\sum_{i,j=1}^{n}[(f(p_{ij})b)W_j]}$$

in which W_j is the n-valued W vector, and the other terms are as above.

It remains only to state the test formula for the long-run requirement:

$$b=\sum_{i,j=1}^{n}[(af(p_{ij})b)W_j]$$

If the equality in this formula holds, the requirement is met.

For this example, $b=3694$, and $f(p_{ij})=P_{i5}-(p_{i1}+p_{i2})$ was chosen after several trials as one manipulation that met the first two requirements of the desired strategy. Substituting appropriate values in the formula, it was found that $a=6.13734$. This strategy can be stated for any starting state i as:

$$\text{Cash}=6.13734(p_{i5}-(p_{i1}+p_{i2}))3694,$$

and can be summarized as a decision vector:

$$\begin{array}{cc} & \text{Starting state} \\ & \begin{array}{c}1\\2\\3\\4\\5\end{array} \end{array} \quad \text{Cash}= \begin{bmatrix} -963.07 \\ -5038.02 \\ +1268.00 \\ +6668.32 \\ +9585.89 \end{bmatrix}$$

The strategy is to withdraw from the cash carryover account in the specified amounts if the yield state this year is either 1 or 2, and to add to this account in the specified amount if the yield state is either 3, 4, or 5. The sum of the products of each component in the cash vector and the corresponding component in the W vector is equal to $3693.99, thus fulfilling (within a cent) the long-run requirements for the strategy.

This is not necessarily an optimum strategy. Optimality should be determined only by reference to some overall criteria that include the possibility of interaction between such managerial activities as credit use, stored grain and non-liquid reserve investments, depreciation and machinery replacement, use of insurance, and so on. A cash carryover strategy is not considered here in such a context, but only as an isolated example.

A Fertilizer Decision

The farmer under discussion wants to know whether or not he should apply fertilizer when he seeds his winter wheat crop this fall. Assume that if between seeding and maturity next year rainfall is very low and the rate of fertilizer application is high, the nitrogen will probably cause a reduction in his wheat yield below what could have been expected with no fertilizer. If rainfall is somewhat below normal or near normal, there will be no yield response to fertilizer. If rainfall is above normal, the yield response will be positive, somewhat in proportion to the increase in rainfall. Lacking data, let us assume that a transition to state 1 will result in a yield reduction of 20 percent, or 3.2 bushels per acre; transition to state 2 will result in a yield reduction of 10 percent, or 6.5 bushels per acre; transition to state 3 leaves yield unaffected; transition to state 4 will result in an increase of 30 percent, or 27.2 bushels per acre; and transition to state 5 will result in a yield increase of 50 percent, or 31.4 bushels per acre. Assume further that the fertilizer can be applied at only one rate, with a fixed cost of $3.50 per acre.

With these data, we can calculate a vector expressing the net gain or loss from fertilizing, if the yield state next year is any one of the five states defined. This vector is:

$$\begin{array}{cccccc} \text{Net} & 1 & 2 & 3 & 4 & 5 \\ \text{fertilizer}= & [-2785 & -2690 & -2023 & +3986 & +7991] \end{array}$$

These elements must be modified by the starting state (yield this year) and by the probabilities of transition to the five states next year. The sum of the product, element by element, of the net fertilizer vector and a row of the P matrix, will be the properly weighted expectation from fertilizing, given this year's yield. Expressed as a gain vector, it is:

$$\begin{array}{cc} & \text{Starting state} \\ & \begin{array}{c}1\\2\\3\\4\\5\end{array} \end{array} \quad \text{Gain}= \begin{bmatrix} +827 \\ -1377 \\ +387 \\ +2256 \\ +3781 \end{bmatrix}$$

This indicates that the farmer should *not* fertilize this fall if his yield this year was in state 2, that he might as well forgo the effort if this year's yield was in state 3, and that he should fertilize if this year's yield was in state 1, 4, or 5.

For comparative purposes, the fertilizer cost can be increased to $6.50 per acre from the $3.50 used above, and all other data held constant. The gain vector in this situation is:

$$\begin{array}{cc} & \text{Years this year} \\ & \begin{array}{c}1\\2\\3\\4\\5\end{array} \end{array} \quad \text{Gain}= \begin{bmatrix} -983 \\ -3125 \\ -1385 \\ +457 \\ +1937 \end{bmatrix}$$

The increased cost of fertilizer has apparently simplified this farmer's decision process. He will fertilize this fall only if this year's yield state was 4 or 5, that is, only when he has a good to bumper crop.

Allocation of Surpluses

The farmer represented by the data in these examples has a long-run probability of about 0.28 of getting a yield that will provide a surplus of income beyond all costs. He is an adept manager, as indicated by the preceding examples of his decision-making processes. As such, he takes care to use his occasional surpluses to increase his working capital, frittering away very little on excess machinery, family living, and so on. It is assumed that there is no additional land for sale in this farmer's area at a reasonable price, so that he will allocate his surpluses between (1) nonfarm investments, which is a form of financial diversification, (2) stored grain, which provides intermediate-term reserves and concomitantly reduces the income-tax bite in the current year, and (3) cash reserves or consumption expenditures.

This farmer cannot predict the size of a surplus, since state 5 is open-ended (a yield $\geqq$ 20.9 bu./acre), but only that there is a 28 percent probability of *some* surplus. He can use the probabilities from the stationary vector W as an allocating device. The formula might be to put $(w_3+w_4)=.60$ of the surplus in nonfarm investments, such as stocks and bonds; hold $w_5=.28$ as stored grain (transferring 28 percent of the potential surplus income to a low-yield state in which the need is greater and the tax less); and hold the remaining $(w_1+w_2)=.12$ as cash savings or an increment to family consumption expenditures. This strategy applies only when yield this year is in state 5. If he follows this strategy, he might want to develop a strategy for cash carryover that differs from the one suggested earlier. Otherwise, he could end up over the long run with too much cash in reserve at low rates of return.

Conclusions

The last sentence or two above suggest that the three examples used here are all rather arbitrary and would be only partial solutions to a decision process in farm financial management. However, they are intended to illustrate possible uses of Markov chain analysis, based on yield data, not to suggest real choices. I hope that the examples do suggest the range of possible applications of this probability calculator to problems of decision-making on dryland farms. Perhaps more important is the suggestion prompted by the results of these illustrative examples, that management strategies or decisions based on probabilities from a Markov process might differ decidedly from the choices we customarily scan in the more usual probability analyses.

This discussion has stopped short of a full treatment of Markov processes.[6] I suspect, for instance, that the whole financial management decision process might be fitted into an absorbing chain for the selection of long-range strategies. This would allow absorbing states at the two extremes of bankruptcy and financial success. The problem would be to estimate mean first-passage times to these absorbing states, given some financial state at the start. One could also set up a series of trapping states, representing levels of equity and risk-taking ability, and calculate probabilities of passage time for each state, transition time within each state, and so on.

But these are not as simple as the exercises above. They must be left to further studies. I believe that Markov chain analysis is applicable to yields of wheat on fallow or other dryland cropping systems. It can be a very useful addition to our traditional bag of analytical tools. It might allow us an even closer approximation to the decisions and barnyard analyses of dryland farmers in the Great Plains than is usually the case, and we might really begin to make some significant progress on solutions to their problems.

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[6] See, for instance: R. A. Howard (*3*), who treats of an iterative procedure somewhat analogous to a linear programing solution. He uses the Markov process to attach probabilities to various possible outcomes of selected strategy sets and operation policies.

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A Method for Evaluating Erosion Control in Farm Planning

By Norman E. Landgren and Jay C. Andersen

Many good studies dealing with economics of conservation have been reported, but some essential questions remain unanswered. What effect does planning the farm to achieve conservation goals have on farm income? How much income could a farmer earn if he ignored conservation? How would income differ between farms planned to keep erosion losses below an acceptable physical level and the same farms planned to get the most profit? This article shows how linear programming can be used to answer questions of this type. The opinions expressed are those of the authors and do not necessarily represent the views of the Farm Economics Division, Economic Research Service, or the U.S. Department of Agriculture.

LINEAR PROGRAMMING has been used extensively to determine that combinations of resources and enterprises that would give maximum profit or minimum costs for a farm. The technique itself is not new. An application of the technique to answer questions like those posed above is, however, a new use for an accepted tool. It gives us a more precise method for determining whether given conservation practices are in fact economic.

The study reported here was developed on the premises that farmers in general do not hold erosion control as a paramount goal; that the goal of most farmers is profit maximization using resources available to them during a relevant planning horizon; and that acceptable farm plans embodying erosion control practices need to be formulated with reference to the particular resource structure, unique tenure expectancy, managerial skill and risk preference of each farm operator. Consequently, the analysis was to determine, for a single farm with a given set of resources and planning horizon of the operator, the economic consequences of formulating the farm plan around specified erosion control goals under different assumptions regarding the availability of operating capital. Economic consequences could be stated in terms of (1) the relationship between net revenue and progressively greater soil loss rates at two levels of capital availability; (2) the soil loss rate which would allow the maximum net revenue farm plan at each assumed capital level; and (3) the effect of progressively higher levels of capital use on net revenue if soil loss were restricted to 5 tons per acre per year.[1]

Characteristics and Resources of the Study Farm

The analysis was applied to a 173-acre farm in southwest Iowa, consisting of 10 acres of bottom land and 163 acres of upland, 129 acres of which are of the Monona soil series with slopes ranging from 7 to 15 percent. The remaining 34 acres of upland soils are of the Marshall series with an average slope of approximately 3 percent.[2] The bottom land soil is Judson silt loam, a colluvial soil formed from eroded material from adjacent upland slopes. The combination and amounts of the soils found on this farm would appear to be fairly representative of farms in the extensive Marshall-Monona transition zone of western Iowa.

Existing building facilities on this farm impose a maximum limit on livestock enterprises of 40 litters of hogs, 100 hens, and 6 dairy cows. Facilities are adequate for extensive cattle-feeding operations. In addition to owning sufficient equipment to care for all enterprises considered as programming alternatives, $8,100 of farm operating capital is available. The only labor available is that of the owner-operator who has a planning horizon of 9 years.

[1] A soil loss rate of five tons per acre per year is usually cited as the maximum permissible rate (or physical planning norm) consistent with productivity maintenance on upland soils of the study farm.

[2] Marshall soils have a slightly higher productivity potential than Monona soils, but both are fertile, well drained, deep loess soils.

Programming Activities and Coefficients

The soils of the study farm were grouped into six land restrictions differentiated by type, slope, and antecedent erosion.[3] Alternative crop activities for upland soils consisted of five rotations (continuous corn; corn, corn, oats and meadow; corn, oats and 2 years of meadow; corn, oats and 4 years of meadow; and continuous meadow). With the exception of continuous meadow, three alternative levels of erosion control (terraced and contoured, contoured only, and neither terraced nor contoured) were permitted for each rotation. Thus, for each of the upland soil types, 13 rotation activities were considered. For the bottom land, only the four rotation activities including some corn, neither terraced nor contoured, were regarded as feasible alternatives. Combinations of rotations and erosion control practices on the various soil types resulted in a total of 69 crop activities for programming.

Livestock activities consisted of one- and two-litter hog systems; dairy cows for butterfat production; cattle feeding enterprises of deferred-fed calves, drylot calves and medium yearlings; a beef cow herd; and laying hens. The alternatives of either buying or selling corn were also included.

Programming restrictions reflected the acres of each soil type on the study farm, the existing facilities to accommodate livestock enterprises, the labor of the owner-operator seasonally distributed among five time periods and the availability of operating capital.

Projected 1965 product prices were used. Production costs reflected the same general price level and "average" production efficiency.

Additional Costs Associated With Erosion

Sheet erosion results in decreased productivity or additional land treatment costs. Land treatment costs associated with an erosion-producing management system change throughout the 9-year planning horizon. In this analysis, two such costs have been treated. They are (1) costs of additional fertilizer necessary to maintain productivity as surface soil is lost, and (2) costs of additional terrace maintenance due to siltation of the terrace channel.[4]

Additional fertilizer costs were estimated from recent agronomic field experiments in the Marshall-Monona transition area of western Iowa.[5] These experiments show that for each inch of surface soil lost, approximately 11 pounds of applied nitrogen per acre are needed to maintain a constant level of corn production. For rotations including small grains or meadow, application of phosphorous to maintain rotation productivity is necessary as surface soil is lost. Annual sheet erosion rates (in fractional inches) were computed for alternative rotations on each upland soil in the study farm.[6] Thus, it was possible for each year during the planning horizon to estimate the additional fertilizer costs due to erosion for each rotation on all of the upland soil types by relating the fertilizer-surface soil substitution rates to the rate of soil loss. These costs ranged from zero to a maximum of $2.88 per acre.

The other element of increased costs due to sheet erosion was computed as the average annual cost of silt removal from the terrace channel accomplished by maintenance plowings with a two-

[3] References to "soil type" in this paper imply a soil area that is unique with regard to series, slope, and antecedent erosion.

[4] Future income flows and costs were not converted to a common point in time. Doing so would not have affected greatly the methodology demonstrated or the results obtained since additional costs necessary to maintain productivity as erosion progressed were a small portion of the total production costs. Moreover, such a precise consideration of time would have required a dynamic programming model accounting for family living expenses, fixed costs, and capital accumulation.

[5] Engelstad, Orvis P. Effect of Surface Soil Thickness on Corn Yield on Marshall and Monona Soils in Iowa. Unpublished Ph. D. Thesis, Iowa State University Library, Ames, Iowa, 1960.

[6] Erosion rates associated with the various alternative rotations were computed through the use of "Browning's Erosion Factors." This method of estimating soil loss considers type of soil, crop management, vegetative cover, supplemental practices, degree of slope, length of slope and antecedent erosion in yielding an average annual soil loss expressed in tons per acre. For details see: R. K. Frevert, G. O. Schwab, T. W. Edminster and K. K. Barnes. *Soil and Water Conservation Engineering.* John Wiley and Sons. New York. 1955. pp. 122–125.

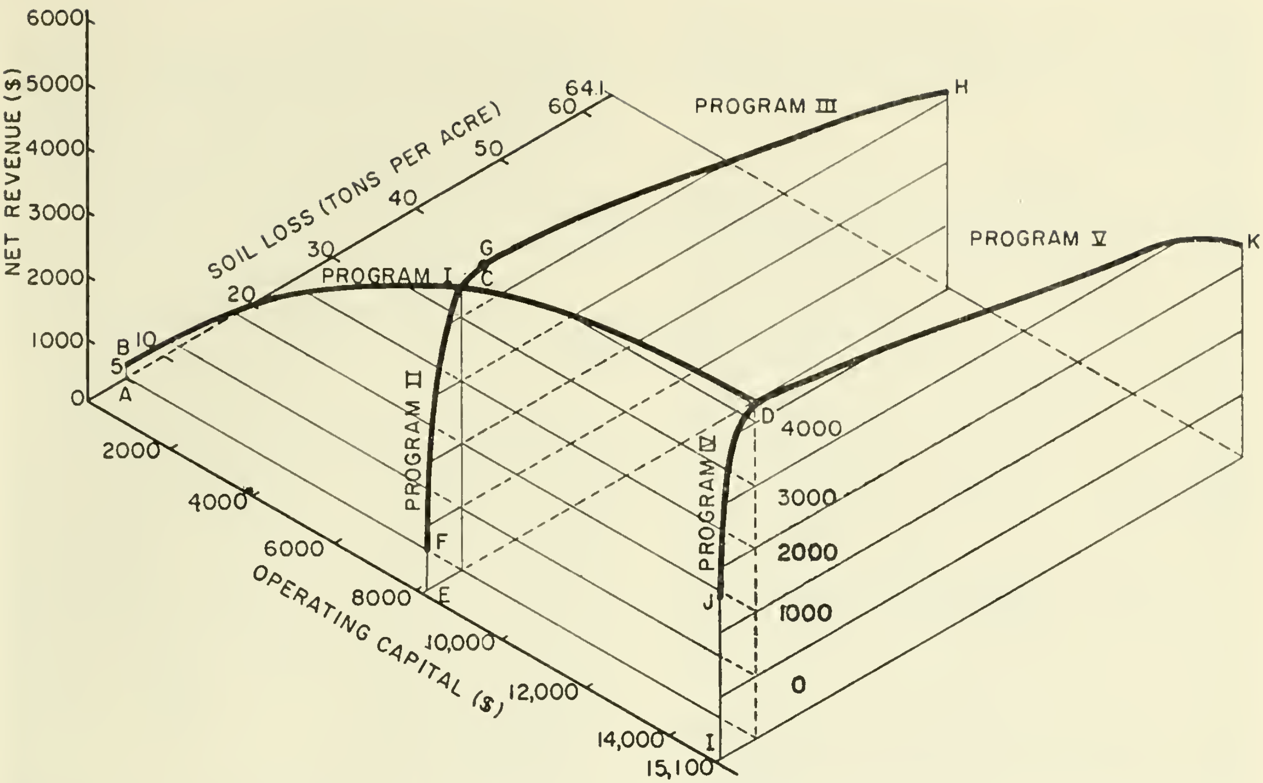

Figure 1.—The relationship of net revenue to capital use and average annual upland soil loss for the study farm.

way plow.[7] For all rotations considered on each terraceable soil type, the average annual silt accumulation was estimated through use of the "Browning Erosion Factors."

Since part of the accumulated silt would be removed incidental to normal plowing operations, only additional plowings necessary to restore the terrace to full capacity and the prorated fixed costs of owning a two-way plow were charged as terrace maintenance costs. These costs ranged from $0.21 (the prorated per acre annual costs of owning a two-way plow) on soil types where extra maintenance plowings were unnecessary, to $1.38 per acre.

The Framework of Analysis

To determine the interdependence among erosion rates, capital availability, and net revenue on the study farm, five variable resource linear programs were solved. The relationships among these programs are shown in figure 1.

Curve ABCD in figure 1 represents the relationship between net revenue and the varied resource, capital, with soil loss restricted to 5 tons per acre on each soil type. For this program (Program I), crop activities on any soil type were limited to those crop sequences and mechanical practices resulting in less than 5 tons per acre annual soil loss.

The other two revenue functions shown in figure 1 were generated by variable resource linear programming with soil loss the varied resource. Curve EFCGH represents a capital availability of $8,100 and curve IJDK a higher ($15,100) capital level. The portion EFCG of curve EFCGH was derived from Program II. The maximum point of this curve is at G where no other combination of crops, livestock and conservation practices, using the limited resources of this farm, could produce additional net revenue. In order

[7] Procedure adapted from George A. Pavelis. Economic Planning Within Small Agricultural Watersheds. Unpublished Ph. D. Thesis, Iowa State University Library, Ames, Iowa, 1958, pp. 61–62.

to determine the nature of the revenue function at average annual upland soil losses greater than those at which net revenue is maximized, Program III was computed. It is represented by the curve segment GH.

But in Program III, soil saved was the varied resource; it was defined as the amount by which soil loss was less than the maximum possible loss. That is, soil saved associated with a particular set of crops and practices on a soil type was computed as the soil loss accruing to that activity subtracted from the soil loss for the most erosive set of crops and practices considered on the soil type. This procedure enabled the derivation of the decreasing portion, segment GH, of the net revenue function. The net revenue functions of Programs II and III necessarily converged since all non-varied resources were available in the same amounts in both programs and as soil saved increased in Program III (moving from H toward G) soil loss decreased by the same amount. Maximum net revenue plans were identical for the two programs; hence, soil losses were the same.

Programs IV and V, represented in figure 1 by curve segments IJD and DK, were identical to Programs II and III except for the additional amount of operating capital available. The effect of capital availability on the most profitable level of conservation was evaluated by relaxing the capital restriction in Programs IV and V to that amount which drove returns to capital to 3 percent in Program I. The profit maximum in Programs IV and V occurred at an average annual upland soil loss of 4.94 tons per acre. This rate of loss and the 5-ton restriction were plotted as point D.

Relationships Between Soil Loss and Net Revenue

Substantial changes in net revenue resulted from varying the rate of soil loss in programming the study farm. Increases in revenue were very rapid, progressing from the lowest rates of erosion possible to the rate associated with the profit-maximizing plan. Revenue decreased slowly as the soil loss rate was further increased. The level of capital availability affected the net revenue functions, farm plans, and associated rates of erosion.

Low Level of Capital Use

Figure 2 shows changes in optimal land use, applied conservation practices, livestock production, and net revenue as average annual soil loss was progressively increased with operating capital restricted to $8,100. The net revenue function EFCGH is identical with the function similarly identified in figure 1.

As the average annual soil loss restriction was increased to the maximum revenue position, the plans indicated continuous corn for most of the farm, with two types of hilly, eroded soil in permanent meadow. The continuous corn was accompanied by contouring and terracing to reduce erosion losses. Because of their high capital and forage requirements, cattle feeding became less profitable as soil loss was increased. Hog production entered the plans as the maximum profit position was approached. Moving beyond the maximum net revenue position, as soil loss was increased, additional continuous corn and fewer conservation practices were associated with decreasing net revenue.

Although the average upland soil loss rate at the maximum profit position was approximately six tons, which is near the often-used five-ton planning restriction, the rates varied for individual soil types. Soil loss rates exceed five tons per acre per year on three of the five upland soil types.

Because the net revenue function increases very rapidly up to the profit-maximizing plan and then decreases very slowly as erosion rates are increased, plans which restrict soil loss too far would have serious income consequences for the owner-operator of the study farm. Land uses and treatment measures much like those found in figure 2 corresponding to a rate of about 1.5 tons of soil loss are frequently recommended. Moving from the optimum plan associated with 6.05 tons of soil loss to the plan with an average of 1.54 tons of soil loss would result in a decrease in net revenue from $4,573 to $2,316—a large income loss due to overplanning.

The highest profit obtainable from the frequently used continuous corn-no-conservation management systems represented on the right-hand portion of figure 2 is also low, reflecting the consequences of inadequate conservation planning.

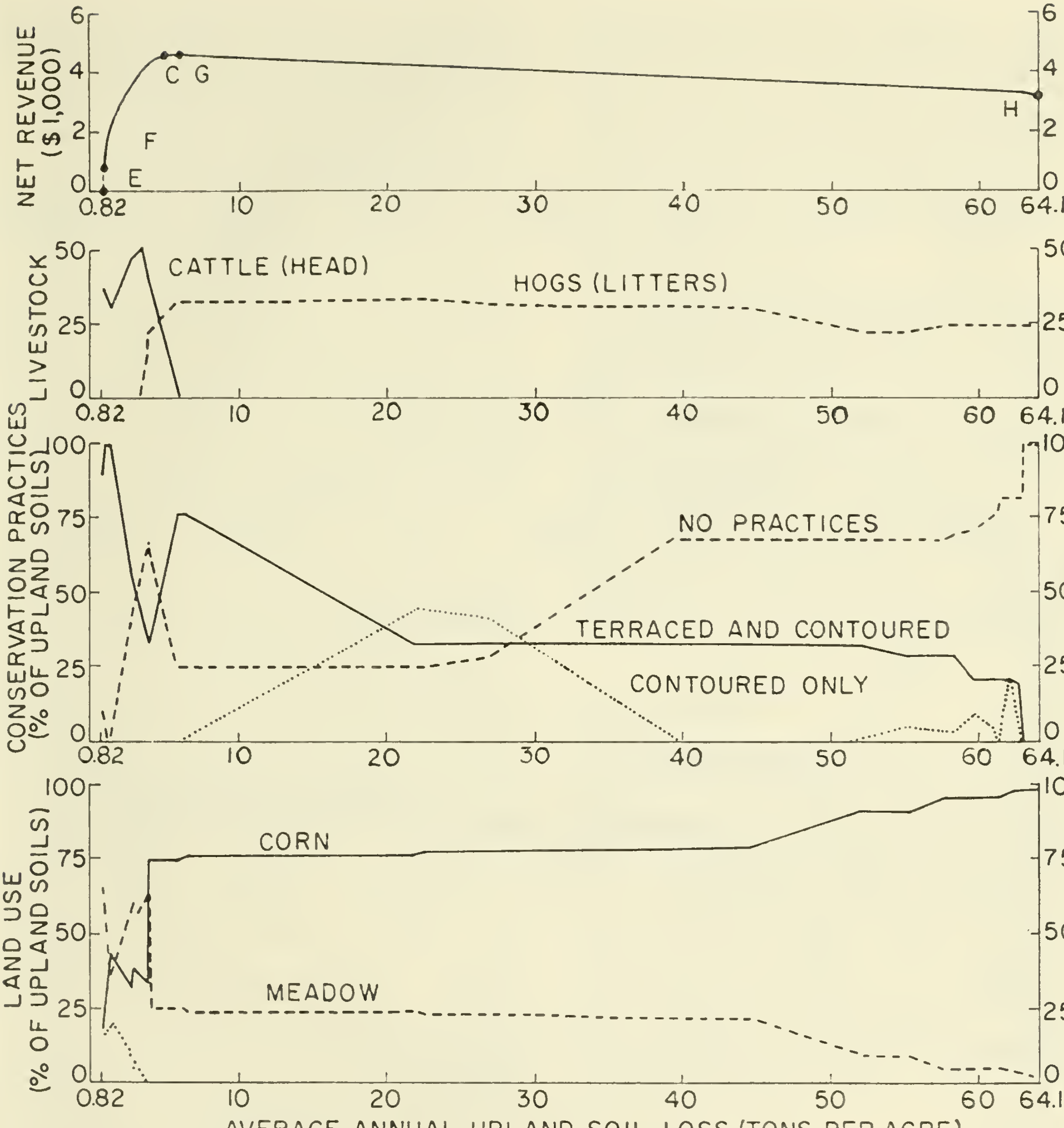

Figure 2.—Land use, conservation practices, livestock systems, and net revenue related to average annual upland soil loss, low level of capital use.

Prolonged excessive erosion rates would likely decrease land values at the end of the planning horizon. Land depreciation costs chargeable to highly erosive management systems were not included in this analysis; these costs would be negligible for profit-maximizing farm plans, and there was no available estimate of their magnitudes at higher soil loss rates.

High Level of Capital Use

An increase in available operating capital to $15,100 yielded programming solutions which in-

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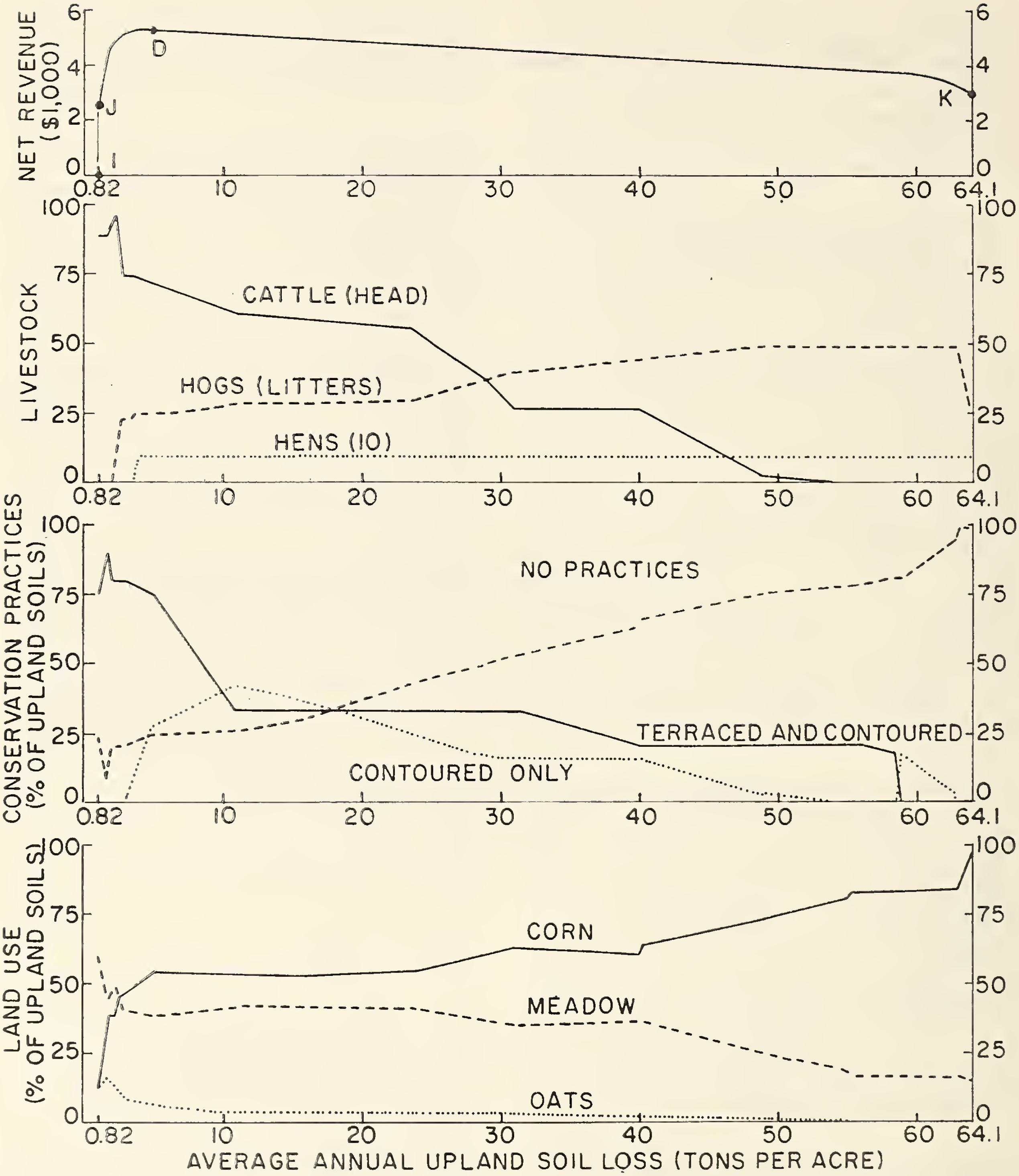

Figure 3.—Land use, conservation practices, livestock systems, and net revenue related to average annual upland soil loss, high level of capital use.

creased net revenue and indicated a slightly lower level of soil loss (4.94 tons per acre per year) associated with the farm plan yielding the highest profits. The shape of the net revenue function derived from Programs IV and V was similar to the one derived for the low level of capital availability. The new revenue function representing the higher level of capital availability is shown as curve IJDK in figures 1 and 3.

The higher level of capital availability allowed more cattle feeding and a shift to forage production on Monona soils, resulting in an increase from \$4,573 to \$5,250 in maximum net revenue plans. Increased forage production in the highest profit plan resulted in the lower rate of soil loss. For both the low and the high levels of capital availability, all rotations which included row crops were designated as being contoured and terraced in the highest profit-producing plan.

Effects of Restricted Soil Loss on Farm Plans

By imposing an annual 5-ton-per-acre limit on soil loss for each soil type, the consistency of this limit with the individual goal of profit maximization was tested. In this program, available capital was varied to show the effect of capital limitations on farm plans with soil loss limited. In general, increasing the level of capital allowed net revenue to increase at a decreasing rate. Program I (summarized in figure 4 and represented by curve ABCD in figure 1) indicated that at extremely low levels of capital availability, crop enterprises alone were in the farm plans. Livestock enterprises became more intensive as capital availability was increased.

The placing of a soil loss restriction on the operator's crop enterprises decreased the net revenue attainable to \$4,386 at the lower (\$8,100) level of capital availability. The imposition of the soil loss restriction, therefore, cost the owner-operator of the study farm \$187 (\$4,573 minus \$4,386) per year. This difference in net revenue was attributable to the soil loss restriction eliminating continuous corn on Monona soils with 11 percent slopes and moderate antecedent erosion as an alternative in Program I. This revenue loss was partly compensated since some of the operating capital committed in Programs II and III to continuous corn was made available for the feeding of cattle.

In the formulation of a farm plan to achieve a given income goal, additional operating capital could compensate for the imposition of a five-ton soil loss restriction. In the limited capital (\$8,100) situation with an imposed soil loss restriction of five tons, marginal returns to additional operating capital were rather high—about 27 percent. Hence, \$8,800 of operating capital in the restricted soil loss program would have achieved the same net revenue as that attainable when operating capital was limited to \$8,100 but soil loss was not restricted.

As available operating capital was increased from the low level to the high level, the farm plans resulting from the soil loss restricting and nonrestricting programs became more similar. When operating capital was set at a level of \$15,100 and soil loss was not restricted to an absolute limit (Programs IV and V), maximum net revenue attainable was \$5,250. At this same level of capital availability when the soil loss restriction was imposed, maximum net revenue reached \$5,219, a difference of only \$31 attributable to the five-ton soil loss limit. This compares with a difference of \$187 in the more limited capital situation.

Limitations of Analysis

Planning Horizons

The length of planning horizon established for the operator of the farm analyzed in this study was 9 years and was reflected in the net revenue coefficients associated with alternative crop activities. A shorter planning horizon presumably would have encouraged more erosive crop rotations, since average annual additional fertilizer costs necessary to replace eroded surface soil would have been decreased for high frequency row-crop rotations relative to less erosive rotations. Conversely, a longer planning horizon probably would have tended to encourage less erosive crop rotations.

Characteristics of Soils

Marshall and Monona soils are characterized by extraordinarily deep loess subsoils which can be made productive by the application of fertilizer. On other soils that are immediately underlain with a rock mantle or nontillable subsoil, substitution of fertilizer for surface soil has limited applicability.

Tenure Arrangements

The study farm was operated by the owner. In the case of tenant-operated farms, if the planning

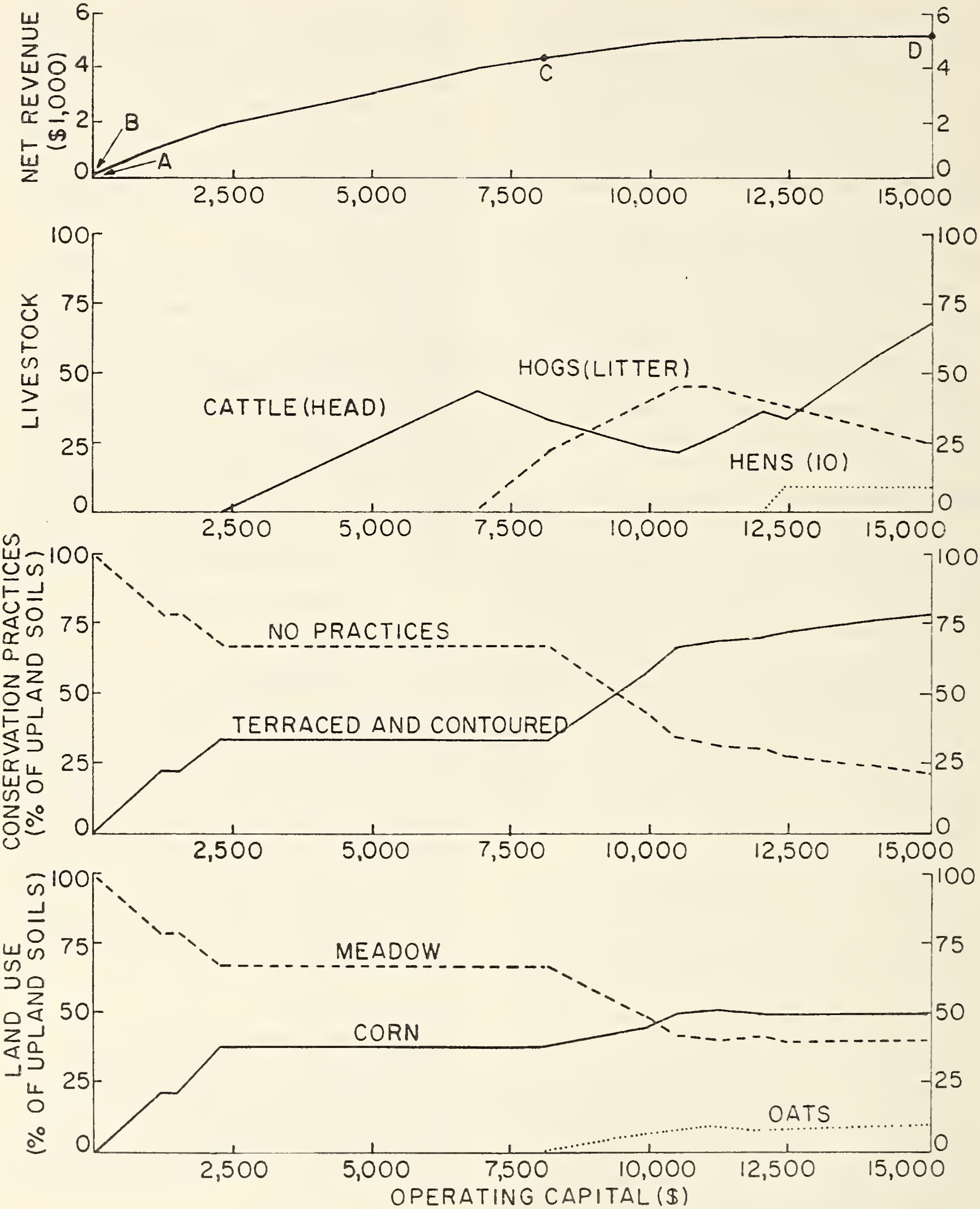

Figure 4.—Land use, conservation practices, livestock systems, and net revenue related to operating capital use, soil loss restricted to 5 tons per acre.

horizons of the tenant and owner were different, conflicts would arise with respect to the profit-maximizing plans and associated rates of erosion. As customary leasing arrangements usually do not result in identical planning horizons, normally it would not be possible to establish a rate of soil loss which would maximize net revenue to both tenants and landlords within the framework of such leasing arrangements. However, it should be possible to devise a compensation structure which would, in effect, make the tenant's and landlord's planning horizons coincide.

Concluding Comments

Our findings indicate that, for the study farm, the rates of erosion that result from highest profit plans do not differ greatly from the frequently used five-ton per acre annual limit. An average annual upland soil loss rate of from five to six tons per acre per year was found to be associated with highest profit plans, though annual soil losses for some soil types were somewhat higher.

Restricting farm plans by an erosion control goal of less than five or six tons per acre per year would sharply decrease profit. On the other hand, net revenue would be decreased only gradually for farm plans yielding more than five or six tons of soil loss per acre per year. From the point of view of the individual farm operator, income consequences of formulating the farm plan around too low an erosion control goal would be far more serious than erring in the direction of inadequate conservation planning.

Formulating farm plans around an absolute erosion control goal of not more than five tons per acre per year for all soil types resulted in slightly decreased net revenue relative to farm plans where soil loss was not considered as a restrictive factor.

Lower erosion rates resulted from increased capital availability as additional livestock entered the plans, forcing a shift from continuous corn to forage-producing rotations. In the highest profit plans, intensive cropping systems, accompanied by contouring and terracing to control erosion, were prevalent on the better soils. Poorer soils were generally devoted to permanent meadow.

In situations other than that represented by the study farm, economic analysis could show more or less conflict between an imposed soil loss limit and a goal of profit maximization. In any event, the determination of the rate of erosion and control methods associated with the net revenue maximizing plan requires economic analysis of the entire complex of soil types, capital and other resources unique to each farm. Planning with reference to physical factors alone may lead to suboptimal plans.

Book Reviews

Alluvial Empire.

By Robert W. Harrison. Pioneer Press, Little Rock, Arkansas. 344 pages. 1961. $8.50.

HISTORY of the Lower Mississippi River Valley usually has been concerned with the "lilac-magnolia" period of *ante bellum* existence—a sort of romantic idyllic life in which no one worked—or if they did, it was done while twanging a guitar or banjo. In *Alluvial Empire*, Harrison has shown us that much of the lower valley history has been concerned with real work—with ditching and draining, with land clearing, and with the innumerable miles of levees for the controlling of floods. Drawing upon his years of study of the economics of the Valley, Harrison has written a sort of summary, yet an all-inclusive work on land clearing, drainage, and flood control. This is the first of a promised two volume work, the second volume to be concerned with a land settlement history.

In the presentation of his material, the author has wisely oriented his approach within the physical aspects of the river watershed and the development of its deltaic flood plain. The herculean efforts required for drainage and flood control are presented, followed by a section on land clearing and the newer technology (new for the Mississippi Valley) of land forming.

One can follow chronologically and organizationally the gradual growth of public interest in economic development of the Alluvial Empire from the early formation of the very small, few-families levee or drainage districts to the concern of the States and finally to the establishment of Federal interests in these matters, particularly in flood control. Perhaps it was to be expected that national concern for extensive destruction to life and property by floods would be a long time developing; however, one is hardly prepared to find it was not until 1928, following disastrous floods in the Valley in 1927, that flood control for the Valley was "at least firmly established as a national responsibility." Since that time, it is apparent that a large proportion of the total Federal effort in flood control has been concentrated in the lower Mississippi Valley or on works that will protect the Valley.

The volume brings up to date the story of Federal contributions by including the more recent Federal actions (Public Law 566, as amended), which have placed the U.S. Department of Agriculture in the flood control picture in its upstream phases.

Harrison has presented a studious work in this volume. It is well written and organized and is a real contribution in the manner of the economic historian. If there is a criticism of the book, it is that there is no specific section or chapter which indicates lessons that have been learned, or that should have been learned in battling the flood and drainage problems of this extensive Empire. Surely out of all the tragedy, the attempts at control and development, the successes and failures, there must be some comprehensive plan or scheme of development to control floods and to drain and develop the still untouched rich lands. Harrison probably did not have this as one of his objectives, but there must be in all the history of the river some "logical" plan of development against which the present segmented and compartmentalized effort might be evaluated.

For students and for those with an interest in the economic history of the Lower Mississippi Valley, this is a "must" book.

John H. Southern

Lecture Series In Honor of the United States Department of Agriculture Centennial Year (1962). Edited by Wayne D. Rasmussen. Graduate School, U.S. Department of Agriculture, Washington 25, D.C. 74 pages. 1961. $1.

THIS BOOKLET contains five lectures by distinguished agricultural leaders, with a central theme of "Growth Through Agricultural Progress." It should be required reading by students

and workers in various fields of American agriculture.

Profile of the USDA—First Fifty Years, is the subject of the first lecture. Vernon Carstensen gives a good picture of the evolution of Federal agricultural activities from a small beginning in the U.S. Patent Office in 1839 until about 1912. Three acts of monumental significance were taken in 1862: (1) Creation of the USDA; (2) The Homestead Act; and (3) The Morrill Act, providing for the Land Grant Colleges. It seems fitting that a Democratic Administration, in true bipartisan fashion, should celebrate in 1962 what Abraham Lincoln and the Republicans initiated a century ago.

Remarkable progress has been made in developing the functions of the USDA—with one exception, namely the establishment of an agricultural museum. In this respect the USDA has gone backwards in the Twentieth Century, contrary to trends in the last generation.

The Department as I Have Known It by Henry A. Wallace is more than a memorial. It was a thrilling experience for those who were fortunate enough to attend this lecture. Mr. Wallace has been "in rather close contact" with the USDA "for more than half of its existence." He grew up with the Department, and, like his father, served as Secretary of Agriculture in a difficult period of agricultural adjustment.

The Land-Grant Colleges: Past and Present by James H. Hilton is an interesting and moving account. The impact of these colleges on our agriculture and our society makes one wonder what would we have done without them. They have provided practical training through teaching, research, and extension, adapted to a dynamic and interdependent society. They also have provided "equal access to educational opportunity" and have had a world-wide influence through the education of students from many countries. Dr. Hilton suggests that "perhaps the single most important overall curriculum problem facing the land-grant colleges and universities today . . . is the need for finding a fruitful balance between specialized training in the professions and sciences on the one hand, and broad education in the social sciences and humanities on the other."

Contributions of Agriculture to Our Economy by Jesse W. Tapp is a scholarly analysis though, in many instances, of a qualitative nature. The role of agriculture is evaluated as a user and producer of capital, as a market for industrial products, and as a producer of exports whereby needed foreign exchange has been obtained. Agriculture's contribution of surplus labor to urban industries, however, through other eyes, might be counted as an urban contribution to the relief of unemployment and underemployment among the surplus farm population. Moreover, except for the reaper, most of the machines associated with the technological revolution in agriculture were invented by urban folks.

Agriculture, Today and Tomorrow is reviewed by Secretary Orville L. Freeman in the fifth and last lecture of the series. Goals and challenges for agriculture are discussed in relation to "the scientific and technological revolution that dominates the age in which we live." One of the main goals discussed is an "adequate" or "fair" reward for farmers, whereas in the United States today "the average per capita farm income is less than half that of the non-farm population." This comparison suggests another challenge, namely to develop a more meaningful comparison in terms of relative well-being. The cost to city folks for eggs, potatoes, and tomatoes of equal nutritional value is considerably higher than for farmers, housing costs more, and the cost of travel to and from work is far greater. Consequently they need a considerably higher money income (net after paying taxes) to live as well as farm families do.

Arthur G. Peterson

Sample Design in Business Research.
By W. Edwards Deming. John Wiley and Sons, New York. 1960. 631 pages. $12.

EVERYONE engaged in statistical surveys will benefit from the many new ideas for enhancing the effectiveness of sampling techniques given in this book. In the main contribution alone the survey statistician and research worker is given reason enough to keep the book for ready reference, because only here can one find the statistical and practical advantages of the "replicated" sample design given in useful form.

For statisticians there is a veritable laboratory of subject matter in household and business inquiries, inventory control, auditing, and related

fields. For nonstatisticians there are lucid explanations of methods for working with difficult populations and for recognizing and handling errors from nonsampling as well as sampling sources.

The 21 chapters are well indexed and organized into three parts on standards of statistical practice, replicated sampling designs, and some theory useful in sampling. Statistical workers as well as teachers and students will be interested in the excellent examples at the end of each chapter and the explanatory appendices for use in setting up field operations. Reference citations are conveniently placed at the bottom of the page where used and provide a thorough background of standard works in sampling. Former associates of Dr. Deming will recognize the author's tireless efforts to improve the quality of surveys and the application of sampling techniques.

The concept of the multiple discipline for combining the efforts of the sampling statistician with those of subject matter specialists is emphasized with specified duty standards and responsibilities for each. This concept is often attributed to the field of operations research. The responsibility for selecting the proper statistical theory is assigned to the statistician; nonsampling errors largely to the subject matter specialist. Problems of field conduct and interviewer supervision are shared by both. The final task of analysis and use of data as an aid for decision-making is not specifically assigned, but the need for executive participation and additional consultants as required is implied.

The project director, administrator, or legal counsel benefits from a refreshing simplicity and clarity of methodology which may otherwise have been ostracized by technical theory and intricate formulation. If there has been need for a breakthrough in sampling to overcome objections from workers demanding more simplified designs, it has now been provided. Dr. Deming has greatly expanded the area of application of the sample and introduced shortcuts and savings to many business operations. In legal evidence the advantage of the sample is demonstrated by a comparison of the operational error in the complete coverage with the sample estimate of error.

Statistical workers familiar with experimental designs and the construction of replications for the purpose of reducing error variance by eliminating heterogeneities through the analysis of variance will recognize the inherent advantages of the "replicated design." They will also be interested in the method for balancing the number of replications against the size of replication.

Viewed as a statistical device borrowed from experimental designs, the concept of the replication for purposes of data collection has had more than a century of use in European agricultural research, such as Rothamsted, England. It is only through bold application of actual survey experience as projected in this book that its usefulness is transferred from the experiment to the survey problem. The use of other experimental designs for stepping up precision and reducing survey costs is also implied and stimulated. More work is needed to overcome a problem concerning statistical inference with regard to population estimates derived from the experiment as distinguished from those of the survey. In time, we might see more use of the general concept of the experimental design, substituting the experimental "treatment" for the "multi-stage" technique, and arranging primary sampling units according to the latin-square or incomplete block factorial. Dr. Deming has projected the experimental device with a zeal that should achieve great progress in the conduct of surveys. He has set the stage for utilizing more of the theory of the experimental design in the survey technique.

The book provides excellent material for use in a practical course in sampling. Part II on sampling practice and part III on sampling theory are especially comprehensive. Supplementary reading in the books by Hanson, Hurwitz and Madow, by Cochran, by Yates, by Sukhatme, and by Mahalanobis is recommended for this purpose, particularly on the subject of multi-stage and cluster sampling. Dr. Deming pointed out in his preface that the book was not intended to displace such standard references.

Much valuable assistance is offered for surveying the elusive or difficult-to-reach universe, especially for cutting through complicated stratifications. Some gifted statisticians may feel that the replicated design does not quite match up to the savings which their mathematical abilities could produce through expert application of the cost function and disproportionate sample allocations for minimizing the total survey cost for a

specified precision goal in the multi-stage situation. For these specialists, Dr. Deming points out that the aim of the book is not limited to statistical and cost considerations and therefore does not guarantee the best possible job of mathematical optimization or of developing "glistening examples of efficiency." Advantages which tend to offset gains available in the more complicated designs are (1) a self-weighting system which is so helpful where computing resources are limited, (2) advanced standards of statistical practice to introduce proficiency in the entire job as well as in the design, and (3) the concept of "equal complete coverage" useful for isolating causes of error not attributable to sampling.

Otto Rauchschwalbe

An Essay on Trade and Transformation. By Staffan Burenstam Linder. John Wiley and Sons, New York. 167 pages. 1961. $5.

THE THEORY of international trade is in the process of undergoing a thorough evaluation and reformulation. This book represents the most recent and perhaps most significant effort to reappraise the validity of traditional trade theory in analyzing the effects of trade under modern economic conditions. It is nothing less than a careful and provocative reevaluation and reformulation of accepted international trade theory.

The theory of international trade can be divided into three distinguishable but interrelated parts—welfare theory, the theory of international trade and economic structure, and the balance of payments theory. This study deals only with the welfare and structural aspects of international trade.

Historically, analyses of the welfare and structural aspects of international trade generally have concentrated on the effects of the opening up of trade under the assumption of a given level of resources of factors of production. The effects of changes in factor prices on factor totals—usually assuming a positively sloped supply curve—has been joined on to the pure reallocation analysis. This approach has led trade theorists to discuss the effects of trade on welfare and economic structure in terms of a comparison between a hypothetical pretrade situation and the situation which emerges when trade has been opened up and the factors of production have been reallocated. The more essential task of studying the impact of trade on the process of growth and stagnation has received scant attention.

Professor Linder has endeavored to go beyond the reallocation approach to analyze the process of economic change through time under the impact of trade. In so doing, he distinguished between the effects of trade on underdeveloped countries, on the one hand, and on growth countries on the other hand. In his analysis of the process of transformation under trade, Professor Linder has departed from the traditional approach of concentrating on differences in the supply of factors of production by emphasizing the importance of differences in production functions—differences which, in turn, are generated by international differences in demand for the various tradable products.

The result is a new understanding of the major factors affecting the structure of goods produced and traded by countries and of the effects of trade on factor prices. This understanding is based on conclusions which are often different from—and sometimes diametrically opposed to—the conclusions derived from the conventional approaches to these problems.

This book makes a significant contribution to economic theory by throwing new light on a wide range of imperfectly understood problems of economic growth and development. The discussion of traditional trade theories and their inadequacies with respect to the effects of trade on underdeveloped countries is of more than academic interest, and should provide a new analytical approach for assessing the effects of trade on developed, as well as underdeveloped, countries. This subject is of utmost practical importance to current "free world" political and economic objectives.

This book should serve as an excellent reference or supplementary text for students of international trade and economic development with adequate training in economic theory. Its usefulness is not limited to those with formal training in mathematics—Professor Linder endeavors to keep mathematics to a minimum. New ground broken by this book should stimulate further research, the success of which will testify to the long-run contributions of this apparently significant piece of work.

Arthur B. Mackie

An Economic Study of Small Farming in Jamaica. By David Edwards. Institute of Social and Economic Research, University College of the West Indies, Kingston, Jamaica, W. I. 370 pages. 1961. $4.

HOW CAN studies of type-of-farming areas in newly developing countries be conducted efficiently to indicate the real needs of farmers for assistance to rapidly increase agricultural production and income? Some type of sample survey of farms is required. This detailed report presents the experience and results of a recent farm management study in Jamaica. It is one of the few reports of such studies generally available to agricultural scientists.

Dr. Edwards, with the aid of three full-time fieldmen, conducted a survey of 87 small farms—less than 25 acres—in nine different parts of the Island by making eight visits to each farm during a year. From 27 of the farms weekly receipt and expense data were also obtained with the part-time help of 20 additional persons living near the farms studied. In the nine chapters comprising the first half of the book, a great deal of information about the farms is presented, including inputs used, production, and income estimates. An essential chapter on methodology describes the sampling procedure among other matters.

The remaining four chapters, which discuss the possibilities for change, are the most interesting and valuable part of the work for those concerned with agricultural development. Most of these chapters take up the farmers' reactions to improved practices suggested by the local agricultural officers. An amusing example follows: "Plant coconuts so that part of the nut shows, not completely underground." The farmer rejected this because if the nut could be seen lying in the ground, his neighbors, his family, or he himself might eat it!

Dr. Edwards concludes his discussion of the farmers' entrepreneurial behavior by stating that given the social and economic environment, he felt the farmers' refusal to adopt most of the improved practices suggested was sound, especially as there is little local experience to demonstrate the economic validity of the practices proposed.

This farm management survey illustrates a kind of study desperately needed for the different type-of-farming areas in newly developing countries. Such a survey is particularly valuable in helping to understand the institutional environment in which farmers operate.

Surveys are largely limited by their nature to descriptive presentations of conditions as they are. Information for the economic analysis of farm decisions concerning possible changes in enterprise combinations, type of technology, profitable levels of inputs, and so on, cannot be obtained successfully with the survey approach. Work in input-output analysis of enterprises and in farm budgeting is required as a complement to the necessary descriptive studies of type-of-farming areas, such as this Jamaican study, if farm operators are going to have the needed information to improve their income and thus aid the agricultural development of their country.

Dr. Edwards gives an excellent report of his work; it could provide guidelines for other studies of this nature. On the basis of conducting similar studies, however, the cost of this particular study in terms of man-power this reviewer feels was excessive. Careful attention was paid to land tenure and possible sources of capital, yet it is regretted that other parts of the institutional environment of the farms were not given more detailed exploration. These might include market outlets, price trends, and alternative job opportunities.

Aside from the undoubted value of the book for those interested in Jamaican agriculture, this work is a good example of the information which can be obtained in underdeveloped areas by carefully designed farm management surveys. Researchers and graduate students concerned with designing surveys in underdeveloped areas will find this thorough and well-presented study particularly useful.

Robert D. Stevens

Fruit and Vegetable Juice Processing Technology. By Donald K. Tressler and Maynard A. Joslyn, in collaboration with a group of specialists. The Avi Publishing Company, Inc., Westport, Connecticut. 1,028 pages. 1961. $19.75.

FRUIT JUICE has gained sharply in popularity among American consumers during the last two decades, to become the leading form in which processed fruit is eaten. In 1961, fruit juices—canned, frozen, and chilled combined—comprised about 60 percent of all processed fruit

consumed, fresh equivalent basis. Underlying this strong upward surge in consumption and related output were striking advances in processing technology. It is this that constitutes the core of the book under review.

The volume—*Fruit and Vegetable Juice Processing Technology*—supersedes one published in 1954—*The Chemistry and Technology of Fruit and Vegetable Juice Production.* The present work includes new subject matter as well as the more recent developments in juice processing technology. It covers juice manufacture work abroad and in the United States. Its 30 chapters are the work of 25 fruit and vegetable specialists in collaboration with the authors.

Following the first chapter, which deals with the historical and economic aspects of juice production, are 18 chapters that cover such general matters as chemistry and characteristics of juices; methods of juice extraction; concentration; flavor retention and quality control; and standards and regulations. The next nine chapters are concerned with the processing and handling of individual and closely related groups of fruit juices, and the final two chapters give similar treatment to vegetable juices. Each chapter ends with an extensive bibliography.

The comprehensive nature of this book and the fluent style of its writing make it a volume that should draw attention of readers far beyond the realm of fruit and vegetable juice processors. The latter, of course, will find it of much interest and value as a source book on the many complexities related to fruit and vegetable juice manufacture, preservation, storage, and handling. Investigators and research people in this field have here a needed and useful reference book.

Economists will find the first chapter of special interest for the many statistical series and charts depicting the growth of the fruit and vegetable juice economy. But the interest of the economist extends to such important matters as kinds and varieties of fruits and vegetables suitable for processing into juice, yields of juice per unit of raw material, quality of product, storage life, deterioration in storage and handling, nutritive value, palatability, and consumer acceptance, all of which are covered in succeeding chapters. Even the general public should find this book of interest, especially for information on particular fruit juices and processing methods.

Ben H. Pubols

The Growth of Cotton Fiber Science in the United States.

By Arthur W. Palmer. The Smithsonian Report for 1960, pages 473–508 (with 8 plates). Smithsonian Institution, Washington 25, D.C. 1961.

COTTON production had its beginnings long before the dawn of the Christian era, but only within the last 50 years a new science of textile fibers has evolved. It combines the classic disciplines of physics, chemistry, biology, and mathematics. This monograph pays tribute to the leadership of Dr. Robert W. Webb in this technological advance in the United States. Dr. Webb's life work has yielded a systematic understanding of the behavior of fibers in mass. The author, former Director of the Cotton Division of the Bureau of Agricultural Economics, held many posts in Government, the last, before his retirement in 1954, General Secretary of the International Cotton Advisory Committee.

Cotton, the author points out, is a strangely inscrutible commodity; it gives up its secrets reluctantly. The difficulty of understanding it grows out of its own complexity.

Dr. Palmer points out that cotton fibers in a bale are never uniform. Always the mass of fiber is a conglomerate of many diverse properties, commingled in a myriad of permutations and combinations. It is these characteristics as well as the physical interaction of fibers of one type against those of other types which govern the properties of the manufactured cloth.

In addressing the National Cotton Congress in 1940, Dr. Webb pointed out that the range of overall cross sections of cotton fibers based on the minimum may vary as much as 4400 percent, the wall thickness 4300 percent, and the fiber length may be as much as 4000 times its width.

To further complicate the general problem, cotton fibers attract and release moisture, causing continuous readjustment to changes in atmospheric humidity, varying their apparent length and the tenacity with which they cling to other fibers when spun into yarns. All these complexities resulted in confusion and controversy and they made it doubly difficult for manufacturers to meet the demand for rigid specifications.

Fifty years ago studies were undertaken in the United States to fix standards of cotton grades. But early efforts to find definite relationships to

known and accepted constants became bogged down in a morass of conflicting results. Such was the unhappy state of affairs in the cotton industry when Dr. Webb was chosen by the Cotton Division of the former Bureau of Agricultural Economics to launch an entirely new attack on these basic problems.

After two years of preparation, a scientific staff was recruited and research facilities were set up. But the apparatus most important to the project did not then exist. That was an instrument for the separation and arrangement of individual fibers in orderly arrays according to length. Dr. Webb designed a fairly simple apparatus which was constructed by Alfred Suter, a manufacturer of scientific equipment. The Webb patent on this invention was immediately dedicated to public use. It was the Suter-Webb Duplex Fiber Sorter.

After the crop failure of 1931, deficiencies in quality resulted in cotton goods being rejected and returned to manufacturers. One frustrated producer enroute to a meeting of the American Society for Testing Materials in New York stopped in Washington and induced Dr. Webb to accept a last minute invitation to attend. Dr. Webb was called on to say a few words at the end of the night session after all of the programmed papers had been presented. The group was electrified by what he had to say and the meeting continued until the early morning hours.

In experiments conducted later, very fine Sea Island cotton fibers were cut to different lengths and commingled in proportion to those of the bread-and-butter upland cottons naturally grown. The yarn so produced from the cut mixtures was found to be 50 percent stronger than comparable yarns spun from the coarser upland cotton of the same length. This was a fundamental breakthrough because the importance of fiber fineness to yarn strength had not previously been understood and appreciated in connection with upland cotton.

The data produced with the Chandler Strength-Tester, which had been developed in Dr. Webb's laboratories, and through other means enabled Dr. Webb to construct a set of basic equations for predicting cotton processing performance and product quality. Dr. Webb's experience in searching out the unknowns in cotton fiber technology and his pioneering in the application of basic data brought new thinking to a great industry.

B. P. Rosanoff

Selected Recent Research Publications in Agricultural Economics Issued by the United States Department of Agriculture and Cooperatively by the State Universities and Colleges[1]

BARNHILL, H. E. RESOURCE REQUIREMENTS ON FARMS FOR SPECIFIED OPERATOR INCOMES. U.S. Dept. Agr., Agr. Econ. Rpt. 5, 31 pp. Feb. 1962.

This is a second progress report to determine the minimum complements of resources needed to enable farm operators on given types of farms in selected areas to achieve specified levels of earnings for their labor and management. Eight types of farms were budgeted for 4 levels of operators' earnings in 15 selected areas. The budgets describe resource requirements for efficiently organized farms making full use of improved practices and available technology.

BLASE, M. G., AND TIMMONS, J. F. SOIL EROSION CONTROL IN WESTERN IOWA: PROGRESS AND PROBLEMS. Iowa Agr. and Home Econ. Expt. Sta. Res. Bul. 498, pp. [275]–324, illus. 1961. (Econ. Res. Serv. cooperating.)

Presents methods of research and findings that show (1) extent of soil erosion in process in western Iowa, (2) factors affecting rate and extent of soil erosion, (3) indications of how erosion control may be made more effective.

BREIMYER, H. F. DEMAND AND PRICES FOR MEAT: FACTORS INFLUENCING THEIR HISTORIC DEVELOPMENT. U.S. Dept. Agr., Tech. Bul. 1253, 108 pp., illus. Jan. 1962.

Study measures the influence on beef, pork, and lamb prices of consumer income, supply of meat, price level, and other price-making factors. Production of meat in the United States increased at a rate of only slightly over one-half of 1 percent per year between 1901 and the 1930's. Its increase accelerated to 2 percent per year from the 1930's to date. The study reports the rapid increase in the economic value of meat accompanying the growth of the total economy during the last 40 years. The record for beef is especially favorable, that for pork less.

BROWN, L. R. AN ECONOMIC ANALYSIS OF FAR EASTERN AGRICULTURE. U.S. Dept. Agr., For. Agr. Econ. Rpt. 2, 50 pp. Nov. 1961.

[1] State publications may be obtained from the issuing agencies of the respective States.

USDA's economists predict that the Far East's agricultural production is not likely to increase fast enough to accommodate both population growth and rising incomes, and that the sizable current flow of food grains from North America (and Australia) will likely expand in the decades ahead. The report describes the agricultural production pattern of the Far East for the past quarter century and gives a breakdown of present food consumption patterns in both quantities and calories, by commodity.

Brown, W. H., and Caton, D. D. cotton farms, san joaquin valley, california: organization, costs and returns, 1947–59. U.S. Dept. Agr., Agr. Econ. Rpt. 3, 27 pp., illus. Dec. 1961.

Net farm incomes on the three types of cotton farms studied—medium-sized cotton-general, large cotton-general, and cotton-speciality—have generally been substantially higher than incomes on cotton-type farms in other areas. More resources are used on these farms than on cotton farms in other regions of the United States.

Cook, F. T., Jr., and Heagler, A. M. factors affecting soybean yields in the delta area of mississippi. Miss. Agr. Expt. Sta. Bul. 630, 8 pp. 1961. (Econ. Res. Serv. cooperating.)

Farmers who consistently produce higher-than-average yields of soybeans in the area studied use (1) a May 10 planting date, (2) rotations, and (3) soybean varieties associated with high yields.

Davan, C. F., Jr., Schmehl, W. R., and Stewart, W. G. fertilizer use and trends for principal crops in colorado. Colo. Agr. Expt. Sta. Gen. Ser. 771, 23 pp., illus. Jan. 1962. (Mimeographed.) (Econ. Res. Ser. cooperating.)

Fertilizer consumption patterns were estimated for hay (primarily alfalfa) and cropland pasture, improved permanent open pasture, corn, potatoes, sugar beets, other crops (sorghum, wheat, oats, barley, rye, proso, dry beans, broomcorn, vegetables, tree fruits, nursery, greenhouse, and wild hay), and nonfarm use throughout Colorado.

Davis, V. W. check the farm lease when you change to field shelling and drying corn. Ill. Agr. Expt. Sta. AERR–47, 27 pp., illus. Apr. 1961. (Mimeographed.) (Econ. Res. Serv. cooperating.)

Describes three methods of sharing operating costs from the standpoint of balancing total costs: (1) Tenants and landlords share 50–50 in costs of fuel and electricity for field shelling, hauling, unloading, and drying; (2) tenants and landlords share equally in costs of fuel and electricity for drying only; landlord pays 3 cents a bushel for field shelling his share; (3) tenant pays all operating costs of field shelling, hauling, unloading, and drying; landlord pays half the difference in total costs to tenants.

Fuller, E. I., and Jensen, H. R. alternative dairy chore systems in loose housing. Minn. Agr. Expt. Sta. Bul. 457, 40 pp., illus. 1962. (Econ. Res. Serv. cooperating.)

Nine adjustment alternatives are discussed with the base period which these adjustments are measured—a typical stanchion barn setup with a 20-cow herd producing grade B milk. The alternative systems are compared with the base system and evaluated in terms of changes in labor, capital costs, and returns.

Gavett, E. E. truck crop production practices, accomack and northampton counties, virginia: labor, power, and materials by operation. U.S. Dept. Agr., Econ. Res. Serv., ERS–45, 51 pp., illus. Dec. 1961.

Most truck crop operations other than land preparation are difficult to mechanize. Thinning and weeding are two preharvest operations still performed largely by hand labor. Harvesting of a majority of truck crops is still predominantly a hand operation.

Hady, F. T. improving incomes of farm people in northern and western florida. U.S. Dept. Agr., Econ. Res. Serv., ERS–36, 27 pp., illus. Dec. 1961. (Fla. Agr. Expt. Sta. cooperating.)

Income from farming is low in northern and western Florida. Farmers in this area contribute less than a tenth to total income. Solution of the low-income problem through agricultural development does not look promising. Nonfarm employment for willing, employable persons seems a more feasible solution. For those too young to work, this program could be expedited by better education including some technical training, and by sound counseling. For those who are too old to make the shift, only limited self help can be expected.

Heid, W. G., Jr. changing grain market channels. U.S. Dept. Agr., Econ. Res. Serv., ERS–39, 27 pp. Nov. 1961.

Describes changes in marketing channels for grain from 1939 to 1959. The study includes the marketing of wheat, corn, oats, barley, sorghum grain, and rye. Individual flow charts for wheat and the five feed grains are presented showing the 1959 movement through the market channels.

Holm, H. M. the agriculture of morocco: programs, progress, prospects. U.S. Dept. Agr., Econ. Res. Serv., ERS–Foreign–11, 35 pp. Nov. 1961.

The Moroccan Government plans to redistribute and consolidate land, implement Operation Plow (Operation Labour) which stresses cooperative farming under modern methods, extend irrigation, and step up programs for reforestation, soil conservation, and livestock improvement. Progress has been slow because qualified extension personnel and technicians are too few, the Moroccan farmer holds fast to traditional methods, the system of land tenure is unwieldy, and financial pressures on the new nation have been extreme.

Howell, L. D. analysis of hedging and other operations in wool and wool top futures. U.S. Dept. Agr., Tech. Bul. 1260, 89 pp. Jan. 1962.

Discusses price risks for wool and wool products and protection afforded by trading in futures markets after the price support program was discontinued in 1955. Included are data on spot prices of Australian wool and wool tops in Boston and prices of wool top futures in London, in addition to prices of domestic wool and products.

HUNTER, J. H., JR. THE ROLE OF TRUCK BROKERS IN THE MOVEMENT OF EXEMPT AGRICULTURAL COMMODITIES. U.S. Dept. Agr., Mktg. Res. Rpt. 525, 29 pp., illus. Feb. 1962.

Truck brokers booked nearly 4 million tons of farm products in 1959. Four-fifths of the interstate tonnage booked was hauled by exempt for-hire carriers (those hauling agricultural commodities exempt from economic regulation by the Interstate Commerce Commission). Business characteristics of the brokerage firms, origin and destination of shipments, layovers, types of services rendered, fees, seasonal activity, and other details are given in the report.

INSTITUTE FOR RESEARCH IN AGRICULTURAL ECONOMICS, OXFORD UNIVERSITY. UNITED KINGDOM: PROJECTED LEVEL OF DEMAND, SUPPLY, AND IMPORTS OF FARM PRODUCTS IN 1965 AND 1975. U.S. Dept. Agr., Econ. Res. Serv., ERS–Foreign–19, 131 pp., illus. Jan. 1962. (For. Agr. Serv. cooperating.)

Forecasts made on the assumption that the United Kingdom would not be a part of the Common Market.

JONES, A. D. WOOL WAREHOUSES: PRACTICES, FACILITIES, SERVICES, CHARGES, PROBLEMS. U.S. Dept. Agr., Tech. Bul. 1259, 54 pp. Dec. 1961.

Researchers studied 149 wool warehouses throughout the United States for information on construction, insurance, and capacity of the warehouses; facilities, personnel, volumes handled; services and costs to producers and buyers, supplementary activities, major problems, and means of improvement.

KEARL, W. G. CATTLE RANCHING IN THE NORTHERN PLAINS AREA OF WYOMING: A PRELIMINARY REPORT. Wyo. Agr. Expt. Sta. Mimeo Cir. 155, 22 pp. 1961. (Mimeographed.) (Econ. Res. Serv. cooperating.)

Includes data on inputs used, organization and operations of ranches, costs and returns, and management practices followed on three different sizes of operations and two different types of ranches—cow-calf and cow-yearling.

LANHAM, W. J., AND BUTLER, C. P. IRRIGATION PRACTICES, COSTS AND RETURNS IN SOUTH CAROLINA, 1956–59. S. C. Agr. Expt. Sta. Bul. 496, 30 pp., illus. Nov. 1961. (Econ. Res. Serv. cooperating.)

Based on farmers' experience from 1956 to 1959, supplemental irrigation of peaches proved to be more profitable than irrigation of any other crop. While increases in net returns from irrigation of other crops averaged lower, irrigation was profitable over the 4-year period for each crop irrigated for those farm operators who already owned irrigation systems.

LEBOVIT, CORINNE, COFER, E. S., MURRAY, J. H., AND CLARK, FAITH. DIETARY EVALUATION OF FOOD USED IN HOUSEHOLDS IN THE UNITED STATES. U.S. Dept. Agr., Agr. Res. Serv., Household Food Consumption Survey 1955, Rpt. No. 16, 55 pp., illus. Nov. 1961.

Report summarizes the information on the nutritive content of household food supplies from the U.S. Department of Agriculture's nationwide Survey of Household Food Consumption made in the spring of 1955.

LINSTROM, H. R. FROZEN FRENCH-FRIED POTATOES: EFFECT OF SIZE OF PIECES ON CONSUMER PREFERENCES. U.S. Dept. Agr., Mktg. Res. Rpt. 514, 40 pp., illus. Dec. 1961

Homemaker satisfaction with frozen french-fried potatoes decreased as the proportion of small and odd-shaped pieces in packages increased. This preference study also provides data on the frequency of use of potatoes in general, homemakers' use of frozen and homemade french-fried potatoes, and the reasons for such use patterns.

LONG, M. E. AUSTRALIA'S AGRICULTURAL PRODUCTION AND TRADE POLICIES AFFECTING U.S. FARM EXPORTS. U.S. Dept. Agr., For. Agr. Econ. Rpt. 3, 62 pp. Dec. 1961.

The similarity between Australia's agricultural commodities and those of the United States will continue to provide keen competition. Australia's increased competition with U.S. products is already evidenced in such major markets as Japan, the United Kingdom, Canada, and West Germany; greater competition is also expected in other Far Eastern and European areas and in Latin America. Agricultural exports account for an annual average of four-fifths of Australia's export revenue, needed to pay for imports of heavy machinery and such raw materials as petroleum and metals.

LOONEY, Z. M., AND HARRELL, E. A. SEED COTTON AND MULTIPLE LINT CLEANINGS AT GINS—EFFECT ON GRADE, PRICE, AND BALE VALUE. U.S. Dept. Agr., Econ. Res. Serv., ERS–43, 15 pp., illus. Dec. 1961.

This report is one of a series relating to different combinations of cleaning and conditioning equipment at cotton gins. It is primarily concerned with the effect on grade and bale value of one through four stages of lint cleaning in combination with different levels of seed cotton cleaning.

MANCHESTER, A. C. THE ORGANIZATION OF THE WHOLESALE FRUIT AND VEGETABLE MARKET IN BOSTON. U.S. Dept. Agr., Mktg. Res. Rpt. 515, 38 pp., illus. Jan. 1962. (Maine Agr. Expt. Sta. cooperating.)

The Boston wholesale produce market is the Nation's fifth largest. The annual volume of fresh fruits and vegetables received has declined about 14,000 carlots during the past 30 years. Net sales of Boston firms were 73,400 carlots in 1958. Direct receipts of chainstores increased about 10 percent between 1936 and 1958 while total receipts in the market, excluding imports, declined about 5 percent.

MCARTHUR, W. C. THE CONSERVATION RESERVE PROGRAM IN GEORGIA: ITS EFFECTS IN THE PIEDMONT AND COASTAL PLAIN. U.S. Dept. Agr.,

Econ. Res. Serv., ERS–31, 29 pp., illus. Dec. 1961.

Effects of the Conservation Reserve Program in Georgia were: (1) Removed land from production on farms where conservation needs were great; (2) provided a means of shifting less profitable units out of production; (3) increased incomes on most participating farms; (4) assisted older farm people who wanted to retire and others who had made the transition from full-time work to part-time or full-time off-farm work.

McCann, G. C. NORTH CAROLINA RURAL ADJUSTMENT STUDIES: A STUDY OF FARM FAMILIES AND THEIR LEVEL OF LIVING-INCOME PATTERNS IN WATAUGA COUNTY, NORTH CAROLINA. N.C. Agr. Expt. Sta., Prog. Rpt. RS–39, 48 pp. June 1961. (Econ. Res. Serv. cooperating.)

Report's principal objective is an analysis of patterns composed of the attributes level of living and net family income. The emphasis of this cooperative project, "Factors in the Adjustment of Families and Individuals in Low Income Rural Areas in North Carolina," is on the identification of the social and psyhcological characteristics associated with various indices of adjustment.

McPherson, W. K., Dixon, L. V., Chapman, H. L., Jr. AN ECONOMIC AND STATISTICAL EVALUATION OF GRADING CATTLE. Fla. Agr. Expt. Sta. Tech. Bul. 632, 57 pp., illus. Sept. 1961. (Agr. Mktg. Serv. cooperating.)

The bulletin consists of a statement of the economic role of grades and its application to livestock and meat; a review of several methods used to evaluate the accuracy of grading livestock; the description of a proposed method for comparing and diagnosing the abilities of individuals to grade cattle accurately; and an illustration of how index of precision scores, mean error of estimate scores, and standard deviation of error scores can be used to evaluate the ability of individuals to grade.

Moffett, R. E., Lundquist, Lynwood, and Johnson, Stewart. THE SCHOOL MILK PROGRAM: EXPERIENCE, EFFECTS, AND POSSIBLE CHANGES. Conn. (Storrs) Agr. Expt. Sta. Bul. 368, 34 pp. Nov. 1961. (Agr. Mktg. Serv. cooperating.)

Of all factors affecting the per-student consumption of milk the most important is price charged. It was estimated that for each decline in price of one cent per half-pint per student, consumption increases .055 half-pints. Rural schools have a higher consumption rate than urban schools. Two possible changes in the Special Milk Program at the Congressional level are considered: including colleges in the Program, and providing free milk rather than low cost milk to elementary and secondary schools.

Nikolitch, Radoje. FAMILY AND LARGER-THAN-FAMILY FARMS: THEIR RELATIVE POSITION IN AMERICAN AGRICULTURE. U.S. Dept. Agr., Agr. Econ. Rpt. 4, 44 pp., illus. Jan. 1962.

The rapid rates of technological advance since World War II have resulted in a sharp decline in total number of farms. For the most part, the farms that disappeared were relatively small, inadequate units falling within the size limit of family farms. However, modern technological advance in farming is not destroying an agriculture composed predominantly of farms falling within the family size limit. The bigger family farms are increasing more rapidly than larger-than-family size farms.

Rogers, G. B. RELATIVE PROFITABILITY OF ALTERNATIVE PROCUREMENT, PRODUCTION, AND SELLING PROGRAMS FOR BROILER PROCESSORS; BASED ON STUDIES IN THE NEW ENGLAND AREA 1957–59. U.S. Dept. Agr., Mktg. Res. Rpt. 516, 37 pp., illus. Jan. 1962.

This study evaluates some of the procurement, production, and selling programs in the broiler industry that plant managers can select. The poultry industry could do better if more emphasis were given to selling the product in forms other than the chilled fresh broiler.

Starbird, I. R., and Vermeer, James. TRACTORS AND PREHARVEST EQUIPMENT, DELTA AREA, MISSISSIPPI: COSTS OF OWNING AND OPERATING, BY SIZE OF FARM, 1957. U.S. Dept. Agr., Agr. Econ. Rpt. 2, 49 pp. Dec. 1961.

Tractor power and related equipment have made possible larger operating units and more efficient use of labor by farmers who are attempting to maintain or improve incomes. Mechanization of commercial farms in the Delta has generally resulted in lower unit of costs of production, thereby partly offsetting the narrowing price-cost margin for crop output in the area.

Stelly, Randall, and Kirby, J. E. DEVELOPING MARKETS FOR U.S. AGRICULTURAL COMMODITIES IN ITALY—AN ECONOMIC EVALUATION. Texas Agr. Expt. Sta., MP–539, 43 pp. Sept. 1961. (For. Agr. Serv. and Econ. Res. Serv. cooperating.)

Market development operations in Italy indicate clearly that properly conducted promotional activities will result in increased sales of U.S. agricultural commodities in foreign countries. This comprehensive evaluation of market development operations under P.L. 480 was undertaken during the fall and winter of 1960 by the Texas Agricultural Experiment Station at the request of the Foreign Agricultural Service.

U.S. Economic Research Service. SPECIAL STUDY ON CIGAR TOBACCO. U.S. Dept. Agr., Econ. Res. Serv., ERS–40, 71 pp. Nov. 1961.

Summarizes findings of a special study group which undertook to determine the effect on the cigar industry and farmers in the United States if Cuban tobacco were no longer available.

Vaughn, G. F. LAND USE IN DELAWARE. Del. Agr. Expt. Sta. Cir. 33, 12 pp., illus. 1962. (Econ. Res. Serv. cooperating.)

Presents present land use in Delaware as an initial step in planning for future land requirements.

WILLIAMS, F. W., AND ALLEN, M. B. THE SOUTHEASTERN VEGETABLE PROCESSING INDUSTRY: LOCATION AND NUMBER OF PLANTS—COMPOSITION, VOLUME, AND VALUE OF PACK, 1960. U.S. Dept. Agr., Mktg. Res. Rpt. 527, 26 pp. illus. Feb. 1962. (Ga. Agr. Expt. Sta. cooperating.)

Vegetable canners and freezers in seven Southeastern States grossed an estimated $47 million in 1960. This report provides detailed data on the volume of vegetables grown in the Southeast and processed in the 7-State region. It is the first in a planned series of research reports on an economic evaluation of processing as a market outlet for vegetables in this region.

Statistical Compilations

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